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THE GLACIAL PERIOD.

BY PROF. IRA MORE.

THE leaves of the Earth's history as they are turned one by one and brought under the inquiring eye of the Scientist, present in their sign language many questions to which a full answer is impossible at the present time, and of which a partial answer must be given with many doubts and misgivings—theory blindly striving to piece together a truth out of the disjointed fragments of our knowledge, and producing, in many instances, a distorted image which may be food for mirth to the more fortunate ages which shall succeed us.

Of these problems the Ice Age, out of which we are just emerging, is the most enigmatical. The first life found the earth's surface of even temperature. The Eozoon of the Archæan, the mollusk of the Silurian, and the fish of the Devonian, lived in quiet, even tempered waters; the first great land vegetation of the Carboniferous made coal-beds, presumably at the poles themselves. In the next great age, when huge saurians led their three-fold life of walking, swimming, and flying, neither tropics nor polar circles formed a boundary to their migrations. The Tertiary shows an increasing difference between poles and equator, and this culminates, not suddenly, but by slow degrees, in a frozen earth; the ice gathering about the poles thickening by slow accretions, and advancing by inches in a century toward the equator, reaching in some places in the northern hemisphere to within 37 degrees of the equator, and approaching still nearer in the southern. But the advance is checked; the frozen edge remains stationary for untold ages, then slowly retreats half-way to its starting points, which position it has maintained, with slight variations of advance and retreat, to the present time.

Facts so startling could hardly fail to set the busy brain of man to speculating upon causes for so astonishing an order of events, and to weaving fine spun theories. These theories may be roughly placed in three classes:

1. Change of currents by elevation or depression of connecting lands.
2. Great simultaneous elevation of polar lands.
3. Varying eccentricity and position of the earth's orbit, by which the poles alternately are subjected to enormous changes of temperature.

With regard to the first of these theories, various suppositions have been made; South America has been connected by uplifted lands with Africa; North America with Europe; Behring's Strait has been narrowed or widened to produce the result; and the Isthmus of Panama having formed the bed of the ocean until the close of the Drift period, was uplifted just in time to pour the warm waters of the Gulf Stream into the

Polar Ocean, driving the ice limit back to its present position. The first three of these are mere assumptions without underlying facts; for the ice-incumbered lands of Behring's Strait have not been examined with sufficient minuteness to determine their age; while, of course, the strata forming the Atlantic sea-bed are not likely to yield up their history to the present generation of seekers. With regard to the Gulf Stream, we may speak more definitely; the coast survey sections commenced by Bache in 1845, and continued from time to time to the present, have given much practical knowledge of this celebrated current; the more to be prized from the fact that no other ocean current has ever been surveyed and measured. From this we learn that its Summer velocity of four miles per hour, about double the Winter velocity, is regularly diminished along the coast northward, until opposite Nantucket it is scarcely one mile per hour; opposite Nova Scotia it can with difficulty be made out at all, and off Newfoundland it is impossible to distinguish it from the surrounding Atlantic waters. A simple calculation based on its diminution so far as traced, brings it to a standstill in long. 53 degrees, less than half way across the Atlantic. It helps in some small measure to moderate the temperature of the Northern Atlantic waters, but it is not a factor in the difference of climate between western Europe and eastern America.

Again, geologists tell us the Isthmus was raised during the Pliocene Tertiary, and not late in the Drift period, as would be needed to sustain the theory. And, as if this were not enough, you will notice that the powerful equatorial current entering the Carribbean Sea runs not toward, but parallel to, the Isthmus. If a chimney through which a strong current of warm air be passing have its wall pierced, the draft through the hole will be *into* the chimney and not *out* of it; so here, pierce the Isthmus by a canal, and the water will flow from the Pacific into the Atlantic. We shall keep our Gulf Stream spite of De Lesseps and all his shoveling crew. Even the Isthmus itself might be swallowed up in the waters, without involving the loss of our much prized ocean river.

Another consideration bears upon this point. The regular ocean current is a modern invention. It depends, of course, upon the difference of heat between equatorial and polar waters. If the equatorial surface waters were 100° F. instead of 80° as at present, the currents would be greatly increased in volume and in velocity; on the other hand, reduce the equatorial heat to 50° F. and the currents would become feeble, mere ghosts or shadows of their present selves. When permanent ice rested at the ocean level at 40° N. latitude, the present Torrid was a cold temperate zone, whose ocean surfaces could hardly have been of higher temperature than 50° Fahrenheit, and currents must have been feeble, local, and uncertain—due mainly to the uncertain and ever varying winds.

From these considerations we shall, I think, be inclined to agree with Dana, that most conservative of geologists, when he says: "The diversion of the Gulf Stream over the submerged Isthmus of Panama into the Pacific, is an hypothesis without facts or probabilities in its favor."

The theory of the simultaneous elevation of polar lands, is somewhat more hopeful than that of currents, as it might, could it have taken place, account for nearly or quite all the phenomena of the Ice Age. It has the great names of Lyell and Dana, as well as a host of lesser note, in its favor. It supposes a great elevation of 1,000 feet or more, of the vast circle of land bordering the Arctic Ocean; and at the same or nearly the same time, the upheaval of lands toward the South Pole. Certain evidences are adduced as partial proof—the great lakes emptied their waters southward; and the ice grooved the rocks and excavated deep and narrow valleys at the sea-shore, now beneath the waters, and known in northern Europe and elsewhere as fiords. These things are quite true, but are capable of a much simpler explanation: the ice and drift blocked the northeastern outlet of the lakes, raised their waters and sent them southward. Even now a rise of fifteen feet would open an outlet for Lake Michigan through the Des Plaines river into the Mississippi. One may walk over the ground from the lake to the river and his eye can scarcely detect a change of level in the eight miles intervening. The fiord sculpturing is easily accounted for with the land at its present level, when we remember that the ice in those latitudes was more than a mile in thickness, and that where the glacier reached the sea, the pressure on the sea bottom would scarcely diminish perceptibly until a depth of several hundred feet had been reached. Kane and others have described the great Humboldt-Glacier as traveling down a valley of western Greenland, bearing its enormous weight of ice to the sea and far into the waters, until the lifting power of the water and the force of the storm waves break off great icebergs. Should this valley become cleared of ice, a fine fiord, making probably one of the best harbors of western Greenland, will be found at its foot.

Elevation or depression of such vast areas of the earth's crust at the same time, is contrary both to reason and experience. An elevation of one portion, means a depression near at hand. If the coast of Norway be rising, that of Sweden is sinking: the bulging out of such vast areas is a well-nigh unthinkable proposition, as nearly impossible as any physical phenomenon can be; the needs of science are not of a nature to justify such desperate hypotheses, and we may regard this theory as only true by a very remote possibility.

The third or eccentric theory known as Croll's was very attractive when it made its appearance some twenty years since. It swept men off their feet as if by one of its own moving floods, and carried them hither

and thither at will. The eccentric form of the earth's orbit and the changing direction of its axis, would give to one hemisphere a longer Summer than Winter for many thousand of years. Its ice cap would diminish while that of the opposite hemisphere would thicken and approach the equator. Then the hemispheres would change conditions; the large ice cap would retreat, while the former favored hemisphere would become frigid. An increase of eccentricity, which reaches its maximum at very long intervals, would greatly increase these differences and account for the glacial phenomena whose history is written on the rocks of so large a portion of the globe. But sober second thought will follow any period of excitement, and men soon saw there would on this hypothesis, be not *one* Ice Age, but *many*; successive layers of unstratified drift material would be sandwiched in between the stratified rocks from the commencement of the Cretaceous to the present time. But no such formations have been found though eagerly looked for. Croll and Geikie contend for two ice ages in the northern hemisphere, separated by a milder interval, but it seems not to be well made out.

Another and very valid objection to Croll's theory is, that the shorter Summer and longer Winter does not necessarily imply a less average of heat received for the year. The sun is now three million miles nearer the earth during the southern Summer than during the northern. The southern hemisphere receives during its longest Summer day about one-fifteenth more heat than the northern hemisphere receives on the 21st of June; and the average amount received for the entire year is slightly greater south of the equator than north of it. True, the southern hemisphere is colder than the northern, owing, no doubt, to the fact of a great Antarctic continent extending for many degrees in all directions from the pole, while the northern polar area is oceanic. The difference is thus probably a constant one; its rocks certainly show the same difference to have existed in the glacial age, and there is no shadow of proof, other than a purely theoretical one, that it was ever otherwise.

There is still a theory to be considered which accounts for the known phenomena and conditions so exactly, that it may become the belief of the future time, as it would probably have been that of the past, had it not been barred by the authority of one illustrious name. It is based upon the instability of the solar system and the gradual approach to the sun. Nearly a century ago the genius of La Place showed by a long and delicate calculation that the solar system is essentially stable; the planets through mutual attractions are ever changing the forms of their orbits, but in periods of longer or shorter duration, return again to the exact orbital form of the earlier time—and so through endless cyclical changes to the infinite of time. The law of endless change, of birth growth and decay, which we see impressed upon every thing about us, does not reach to the relation of planets to each other and to the sun.

Had this been a mere theory it would have shared the fate of endless others long before this. But it was the result of the sublimest calculation of the world's best mathematician, and the average man stands much in awe of figures. But the century since La Place's time is showing the weakness of this part of his work. There is no flaw in his calculations; still the result is wrong. The instrument which he used probably misled him. The Calculus is a wonderful machine, and has done magnificent work since Newton and Leibnitz; but its results have not the absolute exactness of arithmetic. It neglects infinitesimals, and though in ordinary work no appreciable error can be found in its results, still it is true that in delicate calculations, embracing immense periods of time, the very minute error of the shorter process multiplies until it assumes definite proportions; and when man thinks he has grasped an eternal truth, he has but closed his hand upon a very troublesome error. Croll's calculations showing the form of the earth's orbit two or three millions of years forward or backward from the present time, may not be worth the paper they are written on.

Had La Place known what has since been demonstrated, that the Sun's mass has been constantly increasing through the addition of meteoric and cometic matter, thus continually augmenting the force exerted upon the planets and compelling their approach, he might have been led to doubt the correctness of his own conclusions.

The earth, when the first life appeared upon its surface, was much further out in space than now, perhaps nearly to the present position of Jupiter. Its heat came from within, not from the sun. With slowly thickening crust, and diminishing heat, it passed the earlier geological ages. The Tertiary found it nearly in the position of Mars, with a cool temperate climate, somewhat warmer at the equator than at the poles, owing to the increased heat from the sun. But the heat from within is diminishing faster than the sun's heat is increasing; and now comes the frozen age, the icy fingers holding in their grasp both hemispheres; the feeble rays of the Sun having just power enough to keep clear the equatorial lands. A nearer approach and the ice slowly retreats until the present position is reached, and more than half the earth has been cleared of its cold incumbrance: and we may confidently look forward to the time when Wrangell Land and the newly discovered Jeannette Islands shall be fashionable summer watering places for the over-heated, enervated people of Alaska and Labrador. And every planet shall have its day; Mars shall be redeemed from its present icy thralldom, and Jupiter, now in his earliest Archæan age, shall, with his immense bulk, go through all the changes which have marked the stages of progress and decay of the planets within the sweep of his magnificent but ever narrowing orbit.